Cutting Gears in a Lathe

THE MODEL ENGINEER

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In this issue

Photo by] [*C. J. Grose*

This photograph shows an interesting type of locomotive used by the Southern Railway primarily for what is called "interchange goods" traffic; i.e. goods traffic worked from marshalling yards on the S.R., London Area, to other companies' yards in different parts of the same area. There are fifteen of these engines, known as "Class W," numbered 1911 to 1925. They have three simple cylinders.

THE MODEL ENGINEER

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Smoke Rings

A Kodak Model Show

THE Kodak Recreation Society, which has previously distinguished itself by most creditable displays of members' model-making work, is to stage another show at the Kodak Hall at Wealdstone. The dates are November 7th and 8th, and co-operation has already been promised by the Society of Model and Experimental Engineers, the G.E.C. Club, and the Harrow Society. The competitive classes are open to all comers, and awards and certificates will be given to the best exhibits. The classes include locomotives, engines, clocks and tools in the mechanical section, model boats and aeroplanes, and woodwork of all kinds. Entries are invited either for the competition or loan section, and forms and full information may be obtained from the Hon. Exhibition Organiser, Mr. Walter J. Snook, at the Kodak address. It is pleasing to find that the recreative value of model making is still receiving such practical recognition and encouragement in Kodak circles.

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Model Engineering Humour

I SUPPOSE most of my readers are familiar with the humorous mechanical contraptions which have at various times emanated from the fertile brain of that accomplished draughtsman, Mr. Heath Robinson. So ingenious have been his imaginings of how not to do it, that his name has passed into the English language as an appropriate description for a gadget or device which does some mechanical operation in a ludicrously roundabout fashion. I recently renewed my acquaintance with that wonder book of misapplied ingenuity *Railway Ribaldry* which Mr. Heath Robinson produced for the Great Western Railway at the time of their centenary celebration. I am still smiling at his amazing fertility of invention and amusing solutions of railway problems. The thought crossed my mind whether any model engineer had ever attempted to make a working model of a Heath Robinson machine or device from one of his drawings. I think a venture of this kind might prove to be an entertaining experiment, amusing in itself, and the source of much enjoyment to one's friends. I am not forgetting that much of the humour of Mr. Heath Robinson's drawings lies in the creation of the quaint men who so studiously devote themselves to the operation of the ludicrous machines depicted, but the misapplied ingenuity of the devices employed is often so mirth-provoking in itself, that the human figures are not invariably essential to the enjoyment of the joke. I commend the suggestion to those of my readers who are at a loose end for something to make with simple materials, and who think that time is well spent if it can bring a smile to faces which are apt to be subdued by gloomy thoughts of war and other unpleasant things.

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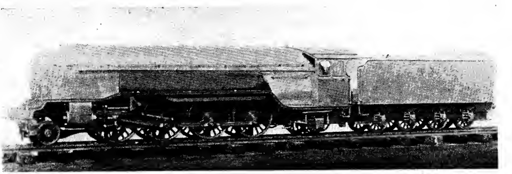
Imagination at Malden

I ALWAYS read the bulletin issued to members of the Malden Society in anticipation of finding a bright idea included somewhere. In Mr. Tonnstein's latest news sheet, which covers three foolscap pages, I observe a useful salvage suggestion, the acceptance of parcels of approved salvage in payment for rides on the Society's passenger track at Beverley Park. Paper, books, and non-ferrous metals are the accepted salvage materials, and the production of one pound of salvage entitles the bearer to a free ride on the track. Other societies please copy. I also read that to facilitate the transport of models and other exhibits for meetings and shows, some of the members are building trailers for their bicycles. I do not think this is altogether a new idea, for I know of cycle transport which has been used in boat clubs for the carrying of large models to the waterside, but in these days of petrol restriction, the existence of one or two transport officers, with cycle equipment, may be a welcome feature of society life for the collection of other models than boats.

Percival Marshall



A $2\frac{1}{2}$-in. Gauge "Cock o' the North"

By "L.B.S.C."

A FOLLOWER of these notes, who is also a keen and energetic member of a flourishing South London M.E. club, purchased a $2\frac{1}{2}$-in. gauge 2-8-2 L.N.E.R. "Cock-o'-the-North," and brought it along recently for a trial run on my road. It is such a remarkable engine that the party mentioned above thinks other readers would be interested in a description of it. I think so too, so here are a few pictures of it, with explanatcry notes. The locomotive is here beside me on the table as I write these words, so I will try to make the description accurate.

She is a "two-cylinder-only" job, although the full-sized engines have three, and she is coal-fired. The main frames are only 1/16 in. thick, although the engine alone is over two feet long, and have two $\frac{3}{8}$-in. rod stays between the coupled wheels to help stiffen the upper part; the lower part has the pony truck bolster and pump stay for "moral and physical support." The buffer and drag beams are only 1/16-in. brass strip, and are attached by pieces of 1/16-in. brass angle; the buffers themselves are of the all-brass "toy" variety, whilst the drawhook is filed up from a bit of the 1/16-in. steel used for frames. There are no screw couplings, only a three-link coupling chain made from 1/16-in. wire, the links being merely bent to shape and the joints left unfastened.

There are no proper hornblocks; but in lieu of them, pieces of 3/16-in. by 5/16-in. steel rod have been riveted at each side and across the top of the axlebox slots, giving the axleboxes a little more bearing surface. The axleboxes are brass, and each is furnished with a single spring, which apparently does no work, as all the boxes are tight against the hornstays at the bottom of the slots when the engine is standing on its wheels. The two sides and top of the leading pony truck are made of a single bit of 1/16-in. sheet bent to shape. Brass axleboxes are fitted to the slots, which are innocent of horncheeks, and a spiral spring is interposed between the top of each axlebox and the crosspiece at top of the truck; but these springs also do no work, as the boxes remain at the bottom of the slots, and the pony truck carries no weight whatever, as there is 1/16-in. clearance between the top of it and the bolster plate above. It swivels on a $\frac{1}{8}$-in. pin in a piece of 1/16-in. plate screwed to the frames. Cast horncheeks and cast dummy leaf springs are attached to the trailing frames; these are very large, as can be seen in the photos., and were apparently intended for $3\frac{1}{2}$-in. gauge. The axleboxes have no radial movement; instead, the axles are given $\frac{3}{8}$ in. sideplay, the frames being bent to allow the necessary clearance. The pony wheels are $1\frac{5}{8}$ in. diameter, and the trailing wheels $1\frac{7}{8}$ in.

The eight-coupled driving wheels are $3\frac{1}{4}$ in. diameter. The rods are fluted, and are milled from steel; but the fit is exceedingly poor for a new engine. The knuckle joints are of the obsolete interlocked pin-drilled type, which I tried and discarded years ago in favour of the correct tongue-and-slot pattern. The former will not stand up to the job in anything above gauge "O," and rapidly become "sloppy."

Cylinders and Motion

Although two cylinders only are provided, even they are ridiculously small for the comparatively large size of the engine, being $\frac{5}{8}$-in. bore and a little over 1-in. stroke. They

are of a peculiar pattern with a diagonal steam chest, with the usual small ports communicating with the cylinder bores by two 1/16-in. holes. The valves are correspondingly small, are mounted on spindles only 3/32 in. diameter, and have a travel of 7/32 in., which, although short, would not be so bad if it were absolute or positive; but owing to the poor fit of the pin joints in the Walschaert's gear, and the link trunnion, the valve can be moved by hand about 1/16 in. without any movement of the wheels, so the valves cut all sorts of capers inside the steam chest when the engine moves. The workmanship bestowed on the cylinder bores and pistons is pretty much the same as on the Great Northern Atlantic locomotive which I have just rebuilt; in fact, I believe the same party was responsible, so will not dilate on that part of the business.

The valve-gear is cut from 1/16-in. steel strip, and is innocent of forked joints except for those at the top of the combination lever, one of which, as you can see from the photo, is so deeply cut that there is hardly any metal left at the bottom of the inside jaw. All the pin joints are made with hexagon-headed screws, and are loose, with the total effect mentioned above. The expansion links are also cut from 1/16-in. sheet, and the suspension is novel in the extreme, as a tag was left on the back of the link after cutting it out. This is bent completely around in hair-pin fashion, and the trunnion pin fixed into it. The pin works in a cast bracket which also supports the guide bars, but is so loose that the link can be easily moved in any direction. There are no die blocks, a loosely-fitting pin fixed in the radius rod working directly in the slot. It is kept from falling out by the lifting arm, which is arranged on the inside of the radius-rod. I might here remark that there is nothing against a "single-sided" valve gear when it is properly designed and fitted, with wide links, proper die-blocks and so on; the present example is neither one thing nor the other. The union-link is not forked, but attached by plain "crankpin" joints to both combination lever and cross-head arm, consequently the bottom end of the combination lever has nearly $\frac{1}{8}$ in. of side movement. The gear is reversed by a lever in the cab, which has no proper quadrant, latch, or trigger for notching up. It is just a plain handle working against a flat plate with three holes in it, a little peg in the lever engaging with the holes, giving fore gear, middle, and back gear positions only; see photo of footplate.

A displacement lubricator is fitted behind the front buffer beam, but it is such in name

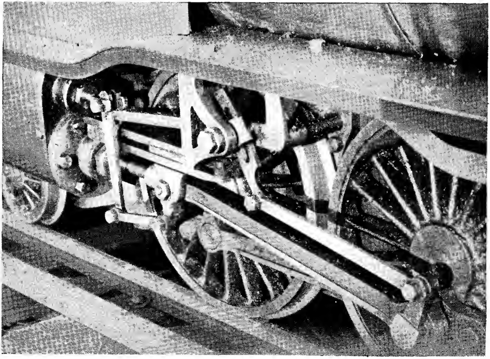


Photo by] **One side of the "works."** [*C. J. Grose*

only, for the oil pipe goes uphill to the cylinder cross-pipe, and the connection is well above the top of the lubricator. There is a cock in the oil pipe, with the handle projecting through the cylinder flap, but its purpose is rather obscure, as there is no oil flow to regulate. When I took off the cylinder cover to measure the bore the inside of the cylinder was bone dry although there was oil in the lubricator—or, shall we say, alleged lubricator?

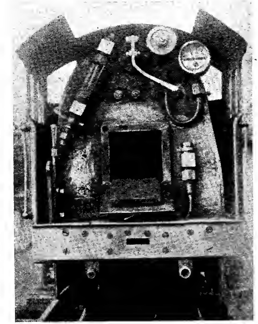


Photo by] [*C. J. Grose*

Slightly "skew-whiff"!

Boiler

The design of the boiler is very poor. It is a huge thing for a 2½-in. gauge locomotive, in fact, it is as big as "Tugboat Annie's," but that is the only likeness, for whereas Annie's makes all the steam required for four cylinders 13/16 in. by 1½ in., this one won't make enough for two ⅝ in. by 1 in. plus. The barrel is 3½ in. diameter, and the overall length is approximately 20½ in. It has a "barn" firebox with a grate 4 in. square. There is no combustion-chamber; and the biggest error the builder made was putting in twenty-seven tubes, over a foot long and only 3/16 in. internal diameter, and leaving out any superheater flues. Apart from their relation of excessive length to diameter, they are far too small in any case for a solid-fuel engine, as I have proved by actual experiments as recently noted in these columns. Although the boiler was stated to the purchaser to be all brazed, the tubes are screwed and soldered in, as there are beads of solder on the smokebox tubeplate, and the screwdriver notches are plainly visible.

The smokebox has a sloping flat top like the full-sized "Cock," but there is no proper dart-and-crossbar fastening to the door. Instead, a strip of iron is hung across the opening and tapped to take a central screw which passes through the door and is ornamented by a couple of dummy handles. In the upper part of the smokebox is a gridiron "condenser." I made a few remarks concerning this type of gadget when describing the "Precursor" rebuild, and same apply here "with knobs on," as my young niece used to remark in her schoolgirl days. There is a built-up twin chimney made from bits of tube and sheet silver-soldered together, but the tubes are too short to ensure proper blast action, even if the cylinders had sufficient vim to raise a decent puff. In the middle of the exhaust cross-pipe between the cylinders there is a junction-piece made from hexagon rod (the pony truck hides it in the picture); two pieces of tube are silver-soldered into this, and project up into the smokebox, one under each chimney tube. There are no proper blast nozzles, the ends of the tubes being merely hammered up. It is here that the builder pulled another delightful "boner." He brought the blower pipe (with hammered-up end) up alongside the rear blast pipe and fixed it to blow up the rear chimney only; consequently, when the blower is in operation, air is drawn down the front chimney and blown out of the back one (vicious circle?) the action on the fire being nil!

Cab Fittings!

The footplate end of the boiler is shown in the picture. The boiler is not mounted vertically on the frames for a start; there is a pronounced leaning to the left. The reverse lever I have already mentioned; the water gauge and check valve can easily be recognised as "regulation catalogue pieces." I don't know what sort of regulator valve is inside the boiler, but I do know that it is "all or nothing" pattern, for as soon as it is opened ever so slightly, it flies wide open. Note the outsize blower valve, and the steam gauge which shows 50 lb. before even the fire is lighted—very optimistic, that! As to the firehole, it is only just above the level of the grate bars, so that every time the door is opened, some of the fire falls out on the footplate, and the unfortunate fireman has to shovel it back again before he can put any more on. Incidentally, the only way you can get the grate in position is through

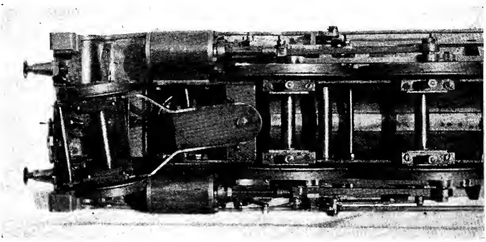


Photo by] **Pit view of front end.** [*C. J. Grose*

the firehole, and the grate is made in three pieces for this purpose. It is a bit of a Chinese puzzle to get them in position and to make them lie down properly. There is no ashpan at all.

A " Working Part "

The boiler is supposed to be fed by a mechanical pump under the engine. This is apparently the working part of a gauge " 1 " tender hand pump adapted to suit eccentric drive. It is mounted on a brass stay like the end of a Distant signal (see picture) and driven by an eccentric of the stationary-engine pattern. It is $\frac{1}{4}$ in. bore and only 3/16 in. stroke, and I fancy there is a big air-gap at the end of the ram, for it absolutely refuses to pump. Even if it delivered properly, the capacity is not nearly enough for the boiler. As to the " plumbing," the picture shows it better than I could describe it. The pump delivers —or is supposed to deliver—into a brass block screwed to the side of the trailing frame. The bypass cock is screwed into the opposite side of the block; the delivery pipe (leading to the check valve on the backhead) into the top; and there is a spare cock underneath to act as emergency petcock and let the air out. There is no separate hand feed line; the hand pump in the tender, which is much the same pattern as the one under the engine, only a little bigger, delivers its feed through the eccentric driven pump. Probably the fact that the latter has to suck its water through the extra valves of

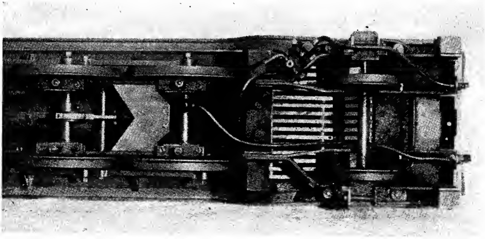


Photo by] **" Non-feed " pump and " plumbing."** [*C. J. Grose*

the handpump has a lot to do with its non-pumping propensities. Apart from two tiny safety-valves with 9/32-in. columns, there are no other fittings on the boiler.

"Trimmings" and Tender

The platework on the engine is neat enough; if the builder had expended the same care in the working parts of the engine as he apparently has in the platework, she would have been a locomotive instead of merely a pretty ornament for a shop window or showcase; but even here there is plenty of room for improvements. For example, there is a gap of 3/16 in. between the top of the buffer beam and the underside of the running-board; the cab windows remind me of the eye-sockets in the skull at the museum, or houses after a visit from Jerry, as they are vacant spaces innocent of glass or mica; and there is plenty of evidence of the application of the soldering iron. The tender is a soldered-up job made from sheet brass. No coal can be carried on it, as there is no retaining plate in front of what would be the coal space, and anything placed on the sloping plate would, of course, simply fall off. The lever of the hand pump projects permanently through a long slot in the tank top—an unsightly arrangement which has not the slightest excuse for perpetuation. The usual little round hole with a domed cap is provided for filling. The tender runs on eight wheels, with the usual cast dummy springs and horns, the spiral springs being in the hoops. The best part about the whole tender is the dummy corridor connection at the back; it is only made of brass and soldered together, but is neat and realistic. But it is far easier to make dummies than the real goods—I know somebody who put one real safety valve and three dummies, all in a bunch, on a L.M.S. boiler!

A Tale of "Whoa!"

The purchaser told me that he asked to see the engine at work before buying it, but was told that it could not be done. He received no instructions how to handle the engine, and not even a firing shovel was supplied, which was extraordinary considering the price charged for the engine. However, being enthusiastic, he bought it, took it home and tried to get up steam. He could get nothing at all out of it, so he took it to a club meeting, and the locomotive section did their best to get it going, with little success. At last one of the members suggested blocking up the front blastpipe and chimney, and trying to get it to go with the single chimney under which the blower jet was located, and eventually they did get a run, but it was "one of sorts." The *modus operandi* was to let it stand until full pressure was reached, and then let it run down the track, which promptly knocked the pressure back, and they had to let it stand and get up more steam. At last, our poor friend, beginning to get downhearted and disappointed, turned to Curly for help, like many others have done before him, and not in vain. He got into touch with me through the secretary of his club, and the two of them brought the engine along here, to see if your humble servant could get anything out of her.

The same procedure was followed as with my own engines. She was seen to be O.K. for oil and water, and lit up, with my electric blower and extension chimney providing draught. Going "all out," it was about 12 minutes before the water boiled, during which time live embers continually fell through the firebars and set my sleepers alight, as there was no ashpan. Then it took several more minutes to get working pressure. When we finally did get it, the engine struggled with her owner as far as the first curve, where she stopped. He got off the car, and then she proceeded without load up the next straight, stopping on the north curve for lack of steam, and I gave her a push and a helping hand to bring her back to the starting place. It was useless to try further, so we took her off. I could see at a glance what was the trouble. Enough said!

The 21-year-old

The poor broken-hearted owner asked if he could see one of my own engines perform, so we lit up old 21-year-old "Ayesha"; and that poor old iron, despite the wearing effects of her long years of hard work, took the three of us around on two cars, making steam so fast that at one point when I had a box full of incandescent fire, I had to put the injector on as well as the pump, to keep her quiet. She kept it up until my passengers got tired of their hard seats. I fancy the club members heard all about it at the next meeting!

Well, all's well that ends well. "Cock o' the North" is staying here; in due course I may pull her to pieces and use such of the parts as can be made serviceable, to build a *real* "Cocky" with three cylinders and a proper boiler. Meantime, our friend now has the rebuilt Atlantic that I recently described, as some consolation for his disappointment, and I have promised, D.V. and circumstances permitting, to build him a real snorter on 3½-in. gauge, provided I am spared to see the end of Adolf & Co., to take along to the club's "fête visits," and pull loads of kids to his heart's content.

What is Science?

By E.T.W.

OUR good friend "L.B.S.C.", in the heading of his article in the issue of August 20th, makes the astounding pronouncement "Science at a Discount!" Without in any way wishing to make a major issue of mere verbiage, or to heckle a distinguished contributor, I would suggest that the phrase is a rather unfortunate one to use as a headline, as it suggests a popular but quite erroneous understanding of the term "Science." To many people, including some who are engaged in technical interests or professions, science is something quite outside their sphere—a mysterious and almost occult ritual which is carried on in equally mysterious and weirdly-equipped "laboratories" by super-intelligent beings whose mental processes are far removed from those of normal humanity.

Applied Knowledge

If one takes the literal meaning of the term "science," it will be found that it implies nothing more or less than applied knowledge, whether such knowledge is of a theoretical or practical nature. It is thus clear that every engineer, whether amateur or professional, can claim to have a part to play in the practice and advancement of science; and that to reject the findings of *true* science is simply to fly in the face of reason. We must, however, be very careful to discriminate between real science and mere pedantic ritual; only too often, we find that the "pseudo-science" which consists of nothing more than the use of unintelligible (and sometimes meaningless) jargon, impresses people much more than the real thing. A person may be hailed by the world as a "scientist" purely on the strength of a propensity for bewildering and confusing people's minds, whereas one who is working diligently and quietly for the enlightenment of humanity passes unnoticed.

Laboratory

There is a similar ambiguity in the acceptance of the term "laboratory," the literal meaning of which is simply a place where problems are worked out in practice. It is clear, therefore, that the humblest workshop may be a laboratory in the truest sense of the term. In all probability, "L.B.S.C." would not be at all flattered if I described him as a scientist, or his workshop as a laboratory, but so far as practical definitions are concerned, all the necessary "ingredients" are present and correct!

Practical engineering represents one of the highest manifestations of the working of science, since there is no engineering process which does not depend upon scientific principles, nor any problem in engineering which does not call for a working knowledge of physical laws. Manipulative skill in the use of tools is in itself a science, if we concede that the popular application of the term to co-ordinated control of the limbs and muscles, in boxing, tennis, and other physical pursuits, is correct.

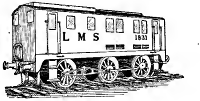
One often hears the expression "blinded with science," but this is the very opposite of the function of science, which is essentially that of sharpening perception rather than of dulling or dazzling it. Speaking as one who, quite definitely, has *not* had what is commonly described as a "scientific education" (what little "science" I possess has been picked up in the hard but very thorough school of practice), I must admit that my pet aversion is the person who tries to show off his superior erudition by "talking over one's head." I am always dubious about theories which cannot be explained in terms comprehensible to a person of normal intelligence. Although science is the most complex and wonderful thing in the world, it is, like the most elaborate machine, built up of individually simple parts. Anyone who has heard or read the lectures of the late Sir Oliver Lodge, for instance, will agree that the most profound scientific subjects can be dealt with in simple and lucid language.

NOT Scientific

The attempt to use pure "theory" or mathematics to solve engineering problems is *not* scientific. It anyone gives me an explanation of a phenomenon or a solution of a problem, in connection with (let us say) port design in petrol engines, consisting of an involved treatise on Boyle's law, or Bernoulli's theorem, or maybe six pages of mathematical formulae and calculations, I may be impressed, but not necessarily convinced. But if, on the other hand, he can give me a practical demonstration of the application of these laws or formulae by means of a simple model or piece of apparatus, I consider that the gulf between theory and practice has thereby been bridged, and the basis established for the application of science to practical engineering.

There have been many so-called "scientists" who have opposed or obstructed progress by "proving," theoretically or mathematically, that locomotives, aircraft

(*Continued on page* 329)



* EDGAR T. WESTBURY'S 1831

Cutting the Transmission Worm Gearing

THE cutting of the worm wheel may be carried out entirely by means of the hob, but the latter is not highly efficient as a cutting tool unless a great deal of care is taken in forming and backing off the cutting edges. It is hardly worth while to do this in the case of a hob made for the purpose of producing only one or two gears at the most; particularly so if it is made of mild-steel, the surface hardening of which does not afford much durability for continued use, in any case. Most of the work in cutting the teeth can be carried out more expeditiously and efficiently by means of a single-point tool set in a rotating cutter bar—literally a fly-cutter. This may be easily made, and enables the tool to be shaped and sharpened to an efficient cutting edge, also to be renewed and re-sharpened, if necessary, during the progress of the work.

For the mandrel or cutter bar, all that is necessary is a piece of round mild-steel, centred to run between centres, cross-drilled to take the cutter, and provided with a grub-screw or other means of clamping the latter (Fig. 134). The bar should not be greater in diameter than the core diameter of the worm pinion; it is advisable to make it exactly the same, as this is helpful when setting the projection of the cutter for forming the teeth to correct depth. Its exact length is immaterial; it should be sufficiently long to avoid risk of the carrier, by which it is driven, fouling the work or affecting accessibility, but not so long that it fails to support the cutter rigidly. About 3 in. to 4 in. long is generally convenient. The cutter should be of round section, so that it can be turned to conform with the lead angle of the teeth, and its shape should correspond with that of the cutter used for the worm pinion; similarly to the latter, its width should be kept on the small side rather than otherwise.

In conjunction with this tool, the duty of the hob is quite light, as it is only used to finish the teeth and correct minor irregularities of their contour; thus it is only necessary to flute or notch the hob teeth to produce cutting edges, and backing-off is unnecessary. The flutes should not be too wide, and should preferably be cut spirally so as to cross the threads more or less at right-angles; they should penetrate slightly below the core diameter, and may be three or four in number. Cutting faces should be approximately radial, and as the hob may be mounted either way round on its mandrel, there is no need to worry about cutting them to suit the direction of rotation—so long as they all face the same way!

All burrs must be removed from the cutting edges before hardening the hob, and the faces should be finished with a dead smooth file so as to produce the maximum keenness. If the hob is of tool-steel, it may be oil-quenched, or hardened out in water and tempered to a medium straw colour. In the absence of specialised experience with

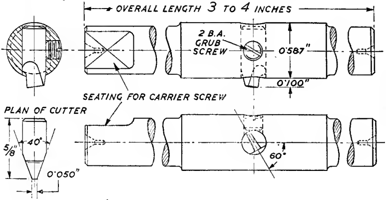


Fig. 134. Cutter bar and fly-cutter for generating worm wheel teeth.

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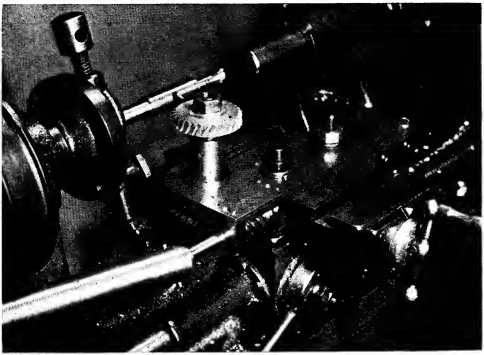
* *Continued from page 276, "M.E.," September 17, 1942.*

tool making, it may be found difficult to temper the teeth evenly all over, in which case oil-quenching will be easier and safer. A medium body oil, such as light mineral machine oil, will serve for this purpose, although by no means so suitable as a proper quenching oil, which is usually of animal or vegetable origin. A mild-steel hob may be case-hardened by any of the standard preparations, but fairly long "soaking" is desirable, to obtain maximum depth of penetration.

The hob must be very securely mounted on its mandrel, so that the risk of its shifting while in use is practically eliminated. For this reason, a nutted mandrel is recommended; if desired, the mandrel used for mounting the worm pinion blank for cutting the teeth may be made to serve this purpose also.

Generating the Worm Wheel

Having produced the fly-cutter and hob, mounted the fixture on the cross slide, and geared it up, there is little that remains for me to say about the cutting operation except "Go ahead with it!" The job is, indeed, a perfectly straightforward one, and can be carried out with the lathe mandrel running at top speed, though common discretion will probably dictate a more cautious approach. The worm blank, securely mounted on its mandrel, is fed gradually up to the cutter while both are rotating under power. At the first scrape of the cutter the setting of the cross-slide index (if one is fitted) is noted, and the feed is continued until the teeth are cut to a depth of 0.100 in. If no such means of gauging the feed is available, the use of a cutter bar turned, as recommended, to the core diameter of worm pinion, and with the cutter projecting 0.100 in. from its surface, as measured by a depth gauge or micrometer, will definitely limit the feed to the correct amount.



Worm wheel in course of being cut.

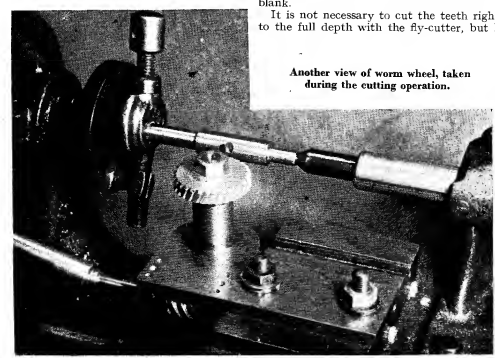
One rather peculiar, but quite logical, fact about the action of the single-point cutter, as applied to this operation, should be noted. As the worm wheel is intended to mesh with a seven-start worm, and the cutter has only one tooth, it is evident that after taking a cut on the first tooth, *it will miss six teeth*, and not cut again until the eighth is reached. This would be rather awkward if the wheel to be cut had a number of teeth representing an exact multiple of the number of starts in the worm pinion—in other words, if the gearing produced an even ratio of reduction. In this

case, the cutter would only form an evenly spaced number of single teeth, and in order to produce the intervening teeth, it would be necessary, after forming the first "set" to the required depth, to run back the work, out of mesh with the cutter, and index the blank, by shifting it on the mandrel, or by disengaging and re-meshing the driving gears, so as to produce another "set" of teeth at the correct angular spacing. This process would have to be repeated as many times as were necessary, according to the number of starts in the worm. In the circumstances, a much more efficient and certain method of generating even-ratio worm gears would be by using a multiple-point cutter—in other words, a hob—for the entire operation.

The ratio of gearing selected for the present purpose, however, makes it possible to cut all the teeth with a single-point cutter, without re-indexing the blank. There is another and not less important reason for using the odd ratio—it distributes wear more evenly, by bringing every tooth in the pinion into mesh with every tooth in the wheel, in the course of successive revolutions, so that local inaccuracies tend gradually to cancel out by wear, instead of becoming worse, as is usual when the same teeth mate every time. This rule is a sound one to follow in the design of transmission gears, except, of course, in such cases as where a definite ratio of reduction is necessary for a specific reason, such as in engine timing gears. Even in the latter, however, it is possible to follow up the principle, by using two stages of odd-ratio gears, one being used to cancel the other. The success of a very well known overhead camshaft motor-cycle engine has been due in no small measure to the use of a patented system of timing gears, which avoids the uneven wear of gear teeth caused by fluctuating loads on the cams, and at the same time allows of "vernier" adjustment of the timing. Reduction gearing for aircraft engines is often made with an odd ratio, partly for the above reason and partly to damp out synchronous vibration of airscrew and engine shaft.

In cutting the 30-tooth worm wheel to mesh with a 7-start worm, the fly-cutter operates on the teeth in the following sequence: 1—8—15—22—29—6—13—20—27—and so on, until all the teeth have been cut. By way of analogy, one might compare the worm with a 7-day week, and the worm wheel with a 30-day month; during seven complete turns of the worm blank, the cutter operates on each of the teeth in turn, in the same way as any given day of the week will, in due course, correspond with each date in the month over a complete cycle of seven months. The action of the cutter is very interesting to watch, especially during the initial stages of the operation, when the first cuts are being taken on the blank.

It is not necessary to cut the teeth right to the full depth with the fly-cutter, but I



Another view of worm wheel, taken during the cutting operation.

have found it desirable to leave as little as possible to be done by the hob. If the point of the fly-cutter is too narrow, the cuts can be widened by operating the longitudinal traverse of the saddle slightly while the lathe is running, but for obvious reasons this must be done very cautiously.

The fly-cutter is then removed and the hob put in its place. Before tightening the carrier on the hob mandrel, the work should be fed up to the hob, so that the latter engages with the partly formed teeth. The carrier is then turned into its driving position, i.e., on the forward side of the driver pin, and clamped securely on to the mandrel. This will ensure that the hob is correctly indexed relatively to the teeth. The operation of the hob will produce a slight curve on the flanks of the teeth, which cannot be obtained with the fly-cutter, except by a somewhat complicated mechanical traversing motion similar to that employed on gear generating machines, such as the Fellowes gear-shaper. If properly made, the hob will leave the teeth highly finished, and thus further increase gear efficiency by reducing surface friction.

A proof of my contention that mechanical rotation of the gear blank is at least highly desirable for hobbing these gears is afforded by the fact that, even after cutting the teeth practically to full depth with the fly-cutter, free rotation of the blank in contact with the hob does not produce such a satisfactory result as when it is power-driven. In experiments made with the driving worm removed from the lower end of the mandrel of the fixture, and the mandrel adjusted to run quite freely, the hob tends to scrape on one side of the teeth, and thereby to widen the spaces as the work proceeds.

The actual efficiency of the gears produced by this process has not been tested, but there is no doubt whatever that they are quite suitable for their intended purpose. With the worm pinion mounted so as to revolve without undue friction, very little torque needs to be applied to the worm wheel to "reverse" the drive; and in common with any well-made worm gearing, it is dead silent at any speed and under any load.

It is quite probable that any lack of specialised knowledge of gear design, and modern methods of gear production, has caused me to tackle this problem by roundabout and unorthodox methods, but I can at least say that the desired result has been achieved, and that neither the apparatus involved, nor the skill to use it, are beyond the resources of the average model engineer. It may perhaps be considered by some readers that the necessity to tackle all sorts of new machining problems may constitute a fatal objection to the construction of an I.C. engine-driven locomotive; but I think most of my readers will agree that there is much to support the other point of view, that it lifts the work out of the rut, and provides the model engineer with new problems, new interests, and new worlds to conquer.

(To be continued)

An Emergency Ball-bearing Repair

Ball-bearings at the present time are practically unobtainable outside essential requirements. A small high-speed electric motor came in for urgent repair, an end-thrust bearing had shed its cage, the cage and balls being found in the field frame of the motor. A new cage was not available from any maker and something had to be done without delay, as speed was an essence of this repair. Any attempt to make a new cage was ruled out of the question and it was eventually decided to take a risk on the following lines. The balls and inner ring were carefully set in place and held in position by means of a handy bolt and washers. A quantity of Babbitt metal was melted to a good temperature, the ball assembly slightly heated, and the Babbitt quickly poured in so as to fill the spaces between the balls and inner and outer rings; the race was now quickly placed upon a wet rag which quickly cooled the job. The race now received attention by way of trimming off all surplus metal, and relieving as far as possible so as to make an improvised cage; after this trimming, the balls were found to be reasonably free in their new housing. The race was assembled and run in, a running test was given for one hour and the performance was perfect. The machine has been in operation now for over three months and appears to be running satisfactorily, and no sign of trouble has shown itself. It would appear that repairs on these lines could, with discretion, be safely carried out in some cases of extreme urgency, even if only as a temporary measure.—J. W. COOPER.

A Cardboard Model Locomotive

By J. A. BUTLER

MR. PERCIVAL MARSHALL'S recent "Smoke Ring" concerning the construction of wood models of mechanical prototypes, has suggested that an account might be submitted of the making of a model locomotive to scale out of an even flimsier material—namely, cardboard.

The locomotive decided upon was the very picturesque narrow-gauge engine "Yeo," which used to run on the Lynton & Barnstaple Light Railway. The choice was made firstly because of a considerable personal interest in these little engines, but it also proved fortunate in that one of the chief difficulties which would otherwise have arisen, namely, that of producing lifelike, spoked coupled- and carrying-wheels did not occur; the former are almost completely hidden by the outside frames, and the latter are of disc form.

The cardboard used for the majority of the work was a thin but fairly smooth-surfaced variety taken from some old cake-boxes, the glazed side being placed outwards generally, as this afforded a smoother ground for the paint.

A drawing was first prepared, as near to scale as possible, from published photographs of the engine, the scale being 1/3 in. to 1 ft. This gave an overall length of 9 in. or so.

The frames were then cut out, using two thicknesses of card glued together for each—fastened to card angles forming the buffer beams in the way advocated by "L.B.S.C." for metal construction.

Building the Wheels

The wheels were built up from a number of discs. These were formed truly circular by placing the card over the top of a squared-off length of metal rod of the right size, and hammering the card lightly all round. Two diameters—for flange and tread respectively—were required for each size of wheel, and the piles of blanks were stuck firmly together with Seccotine. When dry, a 3/32-in. hole was drilled through the centre of each and the wheels were pushed on to axles (made from rounded-off matchsticks)—a fairly tight fit in the holes. As a precaution, a spot of Seccotine was applied to keep the wheels from slipping or moving along the axles. I should perhaps have mentioned that throughout the model all holes intended to act as bearings were stiffened up where possible with a thickness or two extra of cardboard round the hole, to give more bearing surface, and then soaked thoroughly with molten candle-grease, which stiffens the material and acts as a lubricant. Without this, the "bearings" would very quickly become sloppy, with movement of the model. The "journal" parts of matchsticks were similarly treated.

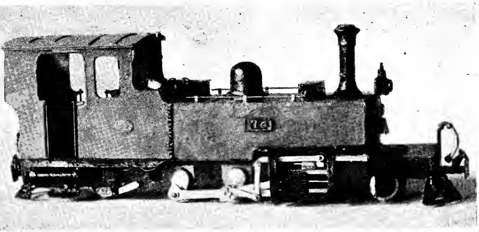
Cranks and Motion Parts

For making the outside cranks (which in the original were polished) and also the motion parts, two or more thicknesses of cardboard were used, stuck together and faced with a layer of smooth aluminium (I think)—coated paper found inside the lids of "Ovaltine" tins. I have not found this particular kind of metal paper elsewhere up to now—it has a coating I should say of about 0.001 in. or 0.0015 in. thick, backed up by stiff paper, and is very suitable for the purpose. Failing this, metal paint would have made a neat job of it, as mentioned by the Editor. The outside cranks were drilled a push fit on the ends of the axles, and were not finally secured in place until the crankpins and connecting-rods had been attached to them, so that it could be seen that the whole assembly revolved freely.

Cylinders were built up from cardboard, the front covers and valve-chest covers being cut from a thicker grade of card and coated with the metallised paper, which had been previously embossed from the underside to represent the holding-down nuts.

Throughout the valve-gear, ordinary, stout domestic pins came in very handy. They were cut short at the back and lightly spread out with a hammer, a spot of Seccotine then serving to make them quite tight in the back members of the pivots. Incidentally, a long pin was used as a fixed sloping guide for an eye-piece, attached to the vibrating lever and radius-rod joint, and sliding up and down the pin. Thus, a simple way was found of imparting a movement to the valve-spindle. As the pin is behind, and overshadowed by, the side-tanks, it is hardly visible at all. If an attempt had been made to reproduce the Joy-type curved guides in cardboard, the friction would almost certainly have been too great to permit of the valve-gear working freely.

As regards the superstructure of the engine, this was cut out from cardboard, and joined at the corners by little angle-pieces Seccotined inside the joint. The boiler was rolled round a piece of one-inch steel rod and stuck along the seam, the smokebox



Mr. Butler's cardboard model of the Lynton and Barnstaple Light Railway locomotive, " Yeo."

door being " dished " by first wetting the cardboard and then pressing it into a former of the required shape, where it was kept in place under a weight for some time. In order to prevent it from gradually losing its form after assembly, a flat disc of thick card was put in the end of the boiler tube first, with a little spigot projecting in the middle, to keep the centre of the dished portion in the proper position.

Boiler Mountings

Plastic wood seemed to offer the most prospects of obtaining lifelike forms for the boiler mountings, so a small tube of this was obtained and, after a little practice, it was found quite easy to build up the contours of chimney, dome, etc., to shape. The main thing, when using this material, is not to be in too much of a hurry ! After forming the rough shape of the part or parts required, they must be put aside for about twelve hours, in which time they will be found to have shrunk considerably and acquired a somewhat crinkly surface. More plastic wood can now be applied to bring the articles to a little larger than finished size, and after a further drying period they are trimmed up with a file.

In this way, chimney, dome, and safety-valve mounting were fabricated, the first two around paper or cardboard skeletons; the head lamp was also moulded from plastic wood.

The method of making the raised name-plates bearing the name YEO may be of interest. It was desired to cast them in plastic wood with lettering in relief, but several attempts with different materials, in which an impression had been engraved to act as a mould, were failures, owing to the plastic wood adhering to the mould in spite of blackleading. Finally, a mould engraved on the flat surface formed by melting candle-grease on to a shallow tin lid to a thickness of about $\frac{1}{8}$ in. was tried, and found completely successful. The impression, left overnight to dry, came away clean, and the same mould could be used a second time.

Final Additions

Such details as tool- and coal-boxes (one of the latter contains some small lumps of coal glued in place), smokebox door fittings, brake pipes, reservoir and cylinder, were finally added ; also, an injector shaped from plastic wood (not shown in photograph, as it is on the other side) with piping made from polished copper wire. Handrails on cab and tanks were made from straightened piano wire, glued on to tiny stanchions of card, covered with the metallised paper previously mentioned.

The engine was painted in the original colour scheme (as near as could be ascertained) as used by the Lynton & Barnstaple Railway before its absorption by the Southern Railway.

I hope, sometime, to build another model locomotive of similar materials, and if possible to make it operate on compressed air, using a full working reversing gear. As far as I can remember, the engine mentioned by Mr. Marshall as being in the Science Museum at South Kensington was a working model in this way, but one can foresee considerable difficulties to be overcome.

[We believe there were two cardboard model locomotives in the Science Museum, South Kensington ; one was a L.B. & S.C.R. " Terrier " 0-6-0 tank, and the other a North London Railway 0-6-0 tank. Each was complete to the last detail, but neither was a *working* model.—Ed., " M.E."]

USING HACKSAWS

How to obtain greater efficiency and make blades last longer

By A. J. T. EYLES

HOWEVER good hacksaw blades may be, they quickly snap in the hands of some model engineers, and though they are fairly cheap to buy, constant breakage can make them expensive. Few hacksaw blades are worn out; more are broken. Too often a model engineer slips a hacksaw in a frame, gives the handle or wing-nut a few turns and starts to cut. Often the blade buckles and breaks or it snaps suddenly, and the fault is improper tension. Like a good violin, a hacksaw blade must be tuned if it is to play its part correctly. And, like the strings of a violin, the hacksaw blade must be kept at proper tension while in use. But care must be used not to strain it too tight, or the pin-holes may pull out. Before starting to cut, make sure that the blade is well strained in the frame. To keep it in "tune"-tension tighten it after a few cuts. Tightening is necessary to take up the slight stretch which may occur.

To obtain the best results a hacksaw blade should be used in a very similar manner to the way in which a skilled mechanic uses a smooth file. Sufficient pressure should be exerted on the forward stroke to prevent the blade sliding over the material, and on the return stroke the blade should be slightly lifted and the pressure released. A speed not exceeding 50 strokes per minute will actually do the work much more rapidly than a faster cutting speed, and with less exertion and fatigue on the part of the user. Rapid strokes tend to draw the temper of the blade, owing to the excessive heat generated, and in consequence the sharp cutting points of the teeth are easily glazed and the blade is rapidly worn out.

It is most important, of course, to select a hand hacksaw blade with the correct pitch of material to be cut. Hacksaw blades are made of various grades of steel, to cut different materials. They are of various thicknesses, ranging from 0.017 to 0.065 in. The pitch may be from 32 down to 12 or less teeth per inch of length. The proper blades for specific purposes are :—

Material to be Cut.	Number of Teeth per Inch.
Aluminium and light aluminium-alloys	10 to 12
Magnesium base alloys ..	12 to 14
Bronze, brass and copper	14 to 16
Tool steels, drill rod and cold rolled steel	16 to 18
Light angle iron	18 to 24
Sheet metal and tubing (over No. 18 s.w.g.)	18 to 24
Sheet metal, tubing, mouldings, etc. (less than No. 18 s.w.g.)	24 to 32

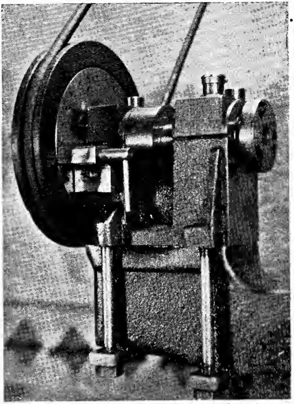
The table below gives a few suggestions to check to help locate and correct hacksaw-blade trouble.

Sheet metal can best be sawed when clamped in the bench vice in company with a board or boards. This combination not only adds stiffness to the thin sheet material, but prevents the blade from biting too freely and breaking its teeth.

Failure.	Cause.	Correction.
Pulling out at pin-hole ..	Blade too tight. Blade twisting in cut.	Reduce tension. Allow just enough to hold blade straight and prevent twisting.
Stripping teeth	Tooth spacing too coarse.	Use number of teeth recommended for material.
Blades breaking	Insufficient tension. .. New blade in unfinished cut. . Side strain on blade. .. Twisting blade.	Make adjustment. Start new cut. Do not bend frame sideways. Use firm, straight stroke.
Premature wear	Pressure on back stroke. .. Insufficient pressure. ..	Lift slightly on back stroke. Cut slowly with pressure on forward stroke.

Making a New HEADSTOCK for a $2\frac{1}{8}$-in. Lathe

By F. D. WOODALL



The new headstock, showing spindle with flanged nose. Note egg-shaped holes to enable chuck to be put on.

IN THE MODEL ENGINEER for February 12th, 1942, there was an article on boring a lathe headstock by sliding it along the bed of the lathe that it was intended for. This was in the nature of a suggestion rather than a description of an operation actually carried out by the writer of the article. I used this method four years before the idea was suggested in the above-mentioned article, but I do not claim it to be an original idea, as it is the more or less obvious way out of a difficulty and may have been used by others.

My lathe is a $2\frac{1}{8}$-in. centre one, new in 1931; early in its career the front bearing broke at the opposite side to the adjusting screw. A new headstock was made but need not be described because it was never satisfactory, it being sufficient to add that at this time the old bearings which were cast integral with the bed of the lathe were sawn off and the casting filed down until the top of the bed and the position of the headstock could both be bedded down to a piece of plate glass.

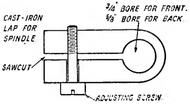
What About It?

When it became obvious that I should have to go the whole hog and make a complete new headstock and spindle, I was faced with the fact that the work would have to be done on the lathe itself and on an Adept shaper, with the exception that the spindle could be roughed out in another lathe—roughed with a capital R in this case. It will be seen that these conditions ruled out any screw-cutting. What was to be done about it? Well, many modern lathes have spindles with flanged noses, not because the builders wish to avoid screw-cutting, but the idea of a flanged spindle came in very useful in my case.

After the whole headstock had been drawn out and a pattern made for the casting, a start was made with the other parts. The spindle was made of English Steel Corporation A. steel and was first roughed out to about 1/16 in. over-size and drilled through 5/16 in. To remove any strains in the metal it was put in the kitchen fire and left overnight. Two short plugs of mild-steel were made, centred at one end, slightly tapered at the other, one was driven into each end of the spindle. It would not have been a good method to have used the ends of the 5/16-in. hole for the centres while finish turning the spindle.

I knew that the lathe as it was would neither turn round nor parallel, so I turned the spindle about 0.002 in. over-size and then set to work with a very smooth file, carefully checking my progress with a micrometer. When the file was first applied to the revolving spindle it showed clearly that it was only touching the tops of a number of circular ridges. By taking care, it was possible to produce a reasonably parallel length where the two bearings were intended to be. While a lathe spindle out of parallel could be made to run all right (in fact, some high-class lathes have a spindle

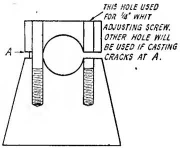
very decidedly out of parallel), it is much more important that it be truly circular. I had every reason to believe that the old headstock turned out of round, so took steps to ensure that the new spindle was not going to reproduce the errors of the old one. Two cast-iron laps were made and applied to the spindle while it was revolving in the



lathe, very smooth emery paste being used as an abrasive. Just as the filing showed up the circular ridges so the laps showed that there were three high points running lengthways, the lapping was continued until there was no sign of unevenness in the appearance of the bearing surfaces, nor any difference in the feel of the lap as it was moved along the revolving spindle. Lapping often leaves a dull but accurate surface, so the lapping was followed by a touch of blue back as used by jewellers.

The driving pulley was a straightforward turning job, being built up from a steel centre-piece, a large washer and a hard-wood disc.

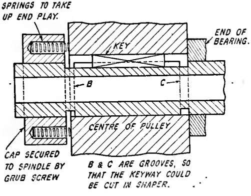
The method of taking up the end play in the spindle is unusual, but in the absence of means for making a pair of orthodox check-nuts it seemed the obvious way of avoiding their use. Two small springs are



all that is needed to prevent any tendency for the spindle to float endwise, although I made provision for four springs.

By the time these details were finished a local foundry had cast a headstock from my pattern. The casting was machined on the Adept shaper on the base up the ends and across the tops of the bearings. I cannot now recall just which face was done first, but it should be noted that there is a step on the base. This is necessary because the stroke of the shaper is less than the overall length of the casting, and in any case there would be no point in machining it the full length, as the face on the lathe bed is shorter than the headstock.

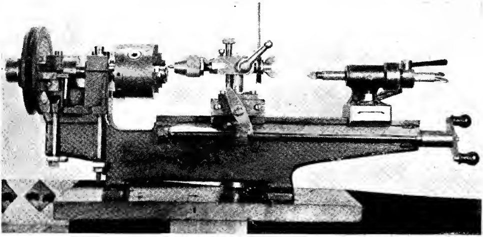
Two pieces of bright mild-steel were sawn off about the same length as the casting from a length of $\frac{1}{2} \times \frac{1}{4}$ in. section, and then planed down on one of the narrow edges to an angle to suit the edges of the lathe bed. By fitting these strips to the headstock I was able to make it slide along the lathe bed ready for boring. A $\frac{5}{8}$-in. diameter boring-bar running between the centres was used for boring the front and rear holes to about 0.002 in. less than 15/16 in. The front of the rear bearing was faced to take a ball-thrust washer, this being done by means of a broad facing cutter that had to be turned



by hand, as the lathe itself would not run slow enough.

As the feed for boring was obtained by using the saddle to push the headstock from the tailstock towards the left, an improvised screw-jack was used to obtain the feed movement when facing the rear bearing.

After removing the casting from the lathe I reamered the two holes with a borrowed reamer to remove the last 0.002 in. I have an idea that many reamers are borers, but in this case it was essential that only the minimum be scraped out to lessen the risk of getting the bearing holes out of line with the base. On the score of simplicity I was in favour of using plain bronze bearings, split at one side, but to avoid the danger of the casting cracking at some future date the arrangement shown in one of the sketches was used. The idea being that if the casting did crack, two screws could be put down the long holes to hold the two fractured surfaces together.



Showing some of the other additions besides the new headstock, including the drilling spindle set-up.

The actual bearings were made from hard bronze, and as they were a plain boring, reaming and turning job, there is no need to describe them except to point out that they were made to push into the casting by thumb pressure ; if they had been tighter, there would have been a risk of them closing in after being split on one side.

Chucks

When all the work was completed and it seemed that I could remove the old headstock, there arose a point that might have been easily overlooked. What was going to fit on the new spindle ? I decided that the 4-jaw chuck would be most useful, so I set its back-plate on the face-plate and bored a recess in it ¼ in. deep and as near 1½ in. diameter as was possible without a plug gauge. The chucks, etc., are held on to the flange on the spindle by three 3/16-in. studs, to save time when changing chucks, etc., the flange has egg-shaped holes so that there is no need to take the nuts off the studs, as they can be passed through the large end of the hole and then the chuck or plate given a twist to put the nuts opposite the small part of the hole. When I had fitted the three studs into the back-plate and made three nuts, I was all ready for the change over.

When the new spindle had got run in and I had managed to set the headstock in line with the tailstock, I carefully turned and polished the flange until it was a snug fit in the back-plate. Once I had got the 4 jaw chuck in use I set to and made a gauge the size of the flange (this was found to be a few thou. less than 1½ in.). This gauge could then be used for making new back-plates, face-plates, etc.

This headstock has now been in use over four years, and if I had to make another I would adopt the same design. Since it was completed I have also made a tool post with height adjustment, a back tool-holder, a three-point fixed steady and a drilling and milling attachment. These, however, are equipment that need not be described, as similar ones have been published before.

What is Science ?

(Continued from page 319)

and radio communication were impossible, but there have been still more whose investigations into pure physics have laid the foundations for great engineering inventions and discoveries.

With regard to the matter of producing a small steam-engine indicator, to which "L.B.S.C." refers in the aforesaid article, I may mention that I do not consider this problem as incapable of practical solution ; and if anyone really wishes to take accurate indicator diagrams, I think I could give him some assistance in the matter. The *real* difficulty in indicator design is getting the working parts to move quickly enough to record the fluctuations in pressure in a high-speed engine ; a subject to which I have given a good deal of attention. While I have not completely solved the problem of indicating engines which run at some thousands of r.p.m. (though I do not despair of ever doing so) I think it would be a relatively simple matter to obtain perfect indicator diagrams from a slow-speed engine, such as that of a model locomotive.

A Method of Cutting Gears
in the Drummond 4-in. Lathe

By G. A. GAULD

THE cutting of a series of small gears to match up with an existing set with reasonable accuracy becomes a simple task by the aid of the "shaping machine" attachment described in the September 3rd, 1942, issue of THE MODEL ENGINEER.

The first and most important job is to form the cutting tool; upon the accuracy of its profile depends the smooth running of the gears. Its general form is shown in Fig. 1. Readers will no doubt be aware that the tooth form for any given pitch varies with the number of teeth in the wheel. Cutters are usually supplied as a set of eight

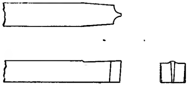


Fig. 1.

to cover from about 12 teeth to a rack. The difference of form is greatest for the smaller gears. For example, the first cutter may apply for wheels of from 12 to 15 teeth, but the last cutter in the series will cover from 50 teeth to a rack. It is unlikely that for any particular mechanism the full range of gears will be required and possibly two or three cutting tools will suffice for immediate needs. All that is necessary is that there should be available a machine-cut gear-wheel of approximately the same number of teeth for use as a template in forming the tool, bearing in mind the remarks above. That is to say, the difference in the number of teeth must be slight in the case of gear-wheels around 20 teeth but if the wheel to be cut is, say, 50 teeth, then wheels of 40 or 60 teeth can be used as templates to give quite satisfactory results.

For gears of a pitch similar or finer than that of "Meccano" gears, the involute curve is of very small radius. The tool was first rough ground to shape, then after making the steel dead soft, the profile was brought up as accurately as possible by means of a $\frac{1}{8}$-in. diameter round file. A small jig was made so that the tool was held radially to the test wheel. By entering the tip of the cutting tool into one of the teeth in the test wheel and holding them against the light, it was possible to get an extremely close "fit." The tool was next tempered, leaving the tip just off dead hard and the profile finally finished off by wrapping some fine emery cloth round the small file and polishing the surface. By grinding the top face, the tool may be sharpened a number of times without appreciably altering the profile.

The tool is set up on its side in the ordinary tool holder on the cross slide. Packings are used to bring it to centre, the final adjustment being made by the well-known feature of rotating the saddle about the lathe bed. (The "shaping machine" attachment does not interfere in any way with this action.) The tool must also be set square to the cut. The "tail" behind the cutting tip must follow in the centre of the cut, otherwise side pressure will be exerted and the tooth cut will not be truly parallel to the axis of the wheel.

A division-plate will be required. It should be made of as large a diameter as possible and drilled with the desired number of $\frac{1}{8}$-in. diameter holes round a circle inside its periphery. It is mounted on the mandrel in the same way as a change-wheel, as shown in Fig. 3. A centre to locate its position is turned and threaded and fixed by two nuts

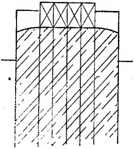


Fig. 2.

in the bracket cast on the side of the head-stock normally used for the first change-wheel stud. If the division-plate is made of fairly thin plate so that it is flexible, it can be "lifted" off the point and turned until the next hole engages, and so on, as required, without loosening off any of the fixings and so avoiding any inaccuracy due to backlash.

Owing to the inevitable "spring" between the saddle and tool and the work mounted

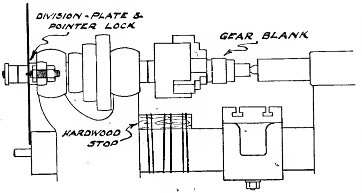


Fig. 3.

between centres, the base of the tooth cut will tend to take the form shown in Fig. 2. As the cut deepens, the effect becomes greater, for a greater amount of metal must be removed with each cut and consequently a greater pressure must be applied. However, by providing " dummies " at each end of the blank and using only the middle portion for the actual gear, the trouble is eliminated. The set-up for a small diameter gear using solid round bar for the gear blank is shown in Fig. 3, and a suitable mandrel when larger gears are cut from discs of 1/16-in. or 3/32-in. plate, is shown in Fig. 4. The diameter of the mandrel should not be less than 5/16 in. for the sake of rigidity and should be turned down from ½-in. diameter bar, sufficient length of the original diameter being allowed to give a good grip in the chuck. If a self-centring chuck is used, the mandrel should be pop marked against No. 1 jaw to ensure that it may be replaced to run true.

Although the shoulder on the mandrel is required to allow of bolting up the blanks, and should coincide with the face of the jaws, there is always the possibility that the mandrel may be pushed bodily into the chuck by the pressure of the cut. Consequently, the packing washer " A " is used to prevent this. Blanks " B " and " D " are the dummies to take out the faulty portion of the cut and the blanks " C " are the actual gear blanks which will be used.

Cuts are taken by the aid of the " shaping machine " attachment, feed being supplied by the cross slide. As the feed must be accurately controlled, the feed wheel must be calibrated. This can be done by dividing it into 83 1/3 parts by a method given in these pages a good few years ago, so that each division represents one thousandth of an inch, or into any arbitrary number such as 100 parts. For the type of gear wheels under consideration, a cut of two to three thousandths is quite sufficient, or less towards the completion of the tooth. Too big a cut may damage the tool or put something out of adjustment and so ruin the job.

It is not advisable to complete each tooth in turn. A series of cuts should be made all round, then another series, and so on, until the gear-wheel is completed. By this method, should the tool require adjustment or resharpening before the whole gear-wheel is completed, then everything will be all right, because any discrepancy will be shared by every tooth right round the wheel. If each tooth were cut to completion in the first instance, then if anything went wrong, the profile or position of the last tooth might be slightly different from that of the first tooth cut, which would lead to a nasty " jag " with each revolution.

It will be noticed that a hardwood stop is shown in Fig. 3. This should be located to stop the movement of the saddle when the tool reaches the end of its cutting stroke. In this way, any danger of the tool knocking up against the hard steel of the chuck jaws is eliminated.

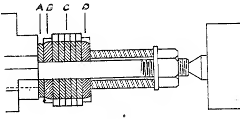


Fig. 4.

While this technique may not be a method of precision, I succeeded in making a fairly complicated gear train for a special cine camera. The mechanism runs at a high speed, as " slow motion " is one of its features, yet the gears run smoothly and the noise level is well below that of some commercial models.

Great pains should be taken to make the tool profile as accurately as possible, and if the cutting process is patiently and carefully carried out, then perfectly satisfactory gears will result.

The One-legged Lathe Stand

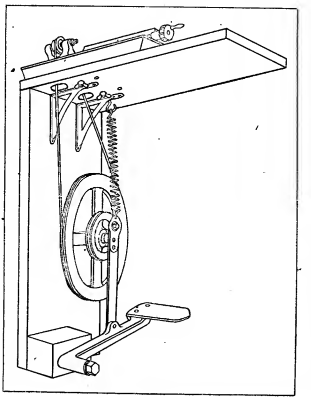
UP to recent times, we had part of a cellar for a workshop fitted up with a bench and a 5-in. lathe ; but now we have no cellar, no workshop, no bench ; and the lathe has gone to make munitions. However, I could not get along without a lathe, although my workshop space was reduced, literally, to a corner of the kitchen table. As I had so little space, I bought a small lathe, a 1⅝-in. Adept ; and having no power supply, I also bought a flywheel and pedal—then I built a stand thus :—

I cut two pieces of 1-in. × 8-in. board, one just as long as the kitchen table is high, the other about two feet long, and screwed them together in an L shape, bracing the angle with two steel shelf brackets. In use, the top board rests on the table, with about a foot overhanging the edge. The overhanging part is supported by the single leg, which also carries the flywheel and pedal.

As the lathe is so small, I can pedal it whilst sitting, but the pedal supplied was designed for use standing, with the pivot at the back and the foot pad in front. I turned it round, placing the pivot in front ; this involved packing it out from the leg, by means of a block of wood, to get the connecting-rod to line up. I also had to extend the foot pad to the right, by riveting on a piece of ⅛-in. steel plate. I can now sit at my work, with my right leg under the table and my left between the table and the lathe leg, working the pedal with my left toes.

I also riveted an extension-piece of thin steel plate to the top end of the connecting-rod, cutting a large hole in it to clear the crankpin. On to this extension is hooked one end of a large tension spring, the other end of which goes on to a hook screwed into the underside of the top board. This spring gives an evener drive to the flywheel, and helps in starting by keeping the crank off the dead centre.

The lathe itself is bolted to the top board with coach bolts and wing-nuts. There are two sets of bolt holes in the top board, so that I can shift the lathe along far enough to allow of driving from the small step of the flywheel on to a 7-in. wood pulley mounted on the tail of the mandrel. This gives a "back gear" ratio. For belts I use soft cotton clothes-line, with wire hook-and-eye fasteners. This gives an excellent drive, and the tension can easily be adjusted by twisting the belt, after the fashion of Messrs. Cheeld's "Torque" belting. The lathe stands in a chip tray, made from a baking tin, which catches most of the swarf.



The advantage of this stand is that when in use it fits on to the kitchen table and is clamped thereto by a G-clamp, so getting all the advantage of the weight and rigidity of the table ; but when not required it is small and light enough to carry out of the room and stow away in an out-of-the-way corner. I could have made it even more compact, by hinging the boards instead of screwing them together so that they would fold, but in this case it was not necessary.—F. P. NEWLEY.

The Workshop and the Kitchen

By W. BIRCHENOUGH, B.Sc.

THE acute shortage of kitchen utensils, coupled with the high prices, will yet become more acute. With an eye to the future, it is well to be able to give any leaky vessels a new lease of life at little cost. Soldering methods are only reliable where the surrounding metal can be thoroughly tinned. With enamelled ware, experience shows that this requirement is seldom, if ever, attainable; because, after removing the enamel round leak hole, the enamel process key grooves, still full of enamel, cannot be cleaned out even with unkilled spirit applied hot. Consequently the operator can easily spend two hours and signally fail to thoroughly tin the surface. The fact is that the problem requires a different treatment.

Fig. 1 shows an effective treatment for any leakage in the bottom or side of any vessel of any metal and surface. The patch

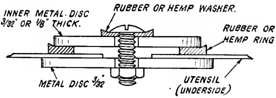


Fig. 1.

will stand boiling water continuously, and will easily outlast the vessel. For application to the curved side of vessel it is only necessary to lodge the discs across two bits of wood and judiciously hammer them to the correct curve to be found by trial on the curved surface. Rubber washers and rings can be cut from old inner tubes of bike or motor tyre. Thin rubber tap washers are admirable. The inner metal disc can be brass, copper, zinc or iron. The outer disc need only be of iron. Even old copper coins bored through centre may be used as inner discs. If discs are not to hand, a piece of 1 in. diameter iron pipe hacksawed along its length and flattened out, will be of correct stiffness. Whilst discs are preferable to squares, the latter may be used. Rubber is becoming scarce; but even if unobtainable, hemp is a sound substitute. Untwist old hemp rope into ultimate strands, pull out straight and make a hemp ring of size required as follows:—Take about 18 in. length of ten or a dozen strands and make a tie (Fig. 2), then continue to wrap the long length *B* all round the circle (Fig. 3), taking care to tuck in and wrap over short end *A* at the finish. If necessary, go round the circle again until the ring is of required thickness.

Failing material for a ring of this construction, one may be cut from stout rag (two or three thicknesses), asbestos

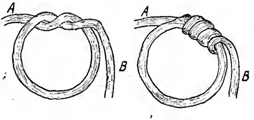


Fig. 2. Fig. 3.

or canvas. The washer to fit under the head of set-screw (Fig. 1) may be made by wrapping a few strands of the rope fibre tightly in the screw threads and continuing under the head until a washer or ring has been formed the diameter of screw head; or, alternatively, a washer may be cut or punched from rag, asbestos, or canvas. The set-screw is preferable in brass, but iron will do; diameter of screwed part to be 3/16 in. or ¼ in. Assemble and fix all in position (as Fig. 1) and tighten by turning the nut, not by revolving screw head, which should be prevented by holding a screwdriver in the groove. Screw tight enough to compress ring and washer and form watertight joint on test. If vessel is for boiling, then the test

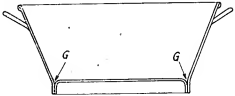


Fig. 4.

is to boil the water, and, if necessary, tighten nut further until vessel passes its test. Diameter of disc depends upon size of leak hole and may be made to cover several. Disc should be large enough to allow a

margin of ½ in. of sound metal round the confines of the leaks. On the other hand, a single hole may need no more than a ⅛ in. set-screw and washers ⅜ in.

So far no mention has been made of leakages which often develop in a different quarter, and for which a different treatment is called for. There is a type of boiling vessel

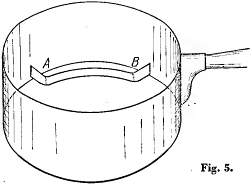


Fig. 5.

(Fig. 4) having a narrow groove *G* round the base; and in this groove leaks often develop owing to the difficulty of drying the groove after use, so causing constant rusting and ultimate perforation. To deal with leaks here it is best to remember the future and treat the whole circle. Clean out the groove and dry if necessary. Give groove a coat, but not a filling, of copal (oak) varnish. When dry give a second coat, and when this is tacky, force or ram into groove some fine hemp (old rope) fibre with screwdriver, a little at a time until it is solid and nearly level with bottom of vessel. Caulk all round the vessel, taking care to leave no fibre ends loose. Finally give a coat of copal varnish on the caulking and allow to dry hard.

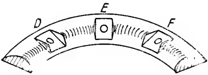


Fig. 6.

The treatment just outlined, whilst sound in principle, is applicable only to those vessels which possess a groove (say ⅛ in. or more) deep enough to accommodate caulking fibre. There yet remains to be considered the ordinary type of vessel which lacks the groove and thus demands a different course of action. Suppose leaks exist from *A* to *B*, Fig. 5. Cut a straight strip of dull tin or sheet iron ½ in. broad and bend it like a curved fender. Plug the leaks with stiff clay outside vessel, place fender in position so as to rest in fillet of clay and be watertight. Pour into the enclosure some melted solder to depth of ¼ in. The result is a piece of solder which is a perfect fit in corner of vessel (Fig. 6). When cool, remove it and file 3 bevels *D*, *E*, *F*, approximately at 45°, and bore each to take a set-screw ⅛ in., the holes to make to corner of vessel. Cut out a rubber or hessian or linen (2 or 3 thicknesses), pad to go under the angle piece. Clean out the clay fillet, place all in position, and wrap the set-screw threads just below the heads as described for Fig. 1. Put on the

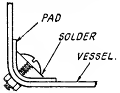


Fig. 7.

nuts and tighten on these alone, not by turning screw heads. Tighten the two end ones equally a little at a time. Lastly, tighten the centre one. Vessel (Fig. 7) may then be tested and, if necessary, tightened further until no sign of leak is traceable. Solder may be melted in old iron spoon. See vessel is level when pouring in the solder. Fillets of clay are required at *A* and *B*, as well as the outside bottom edge.

For the Bookshelf

Aircraft Instruments: Their Construction and Maintenance, By J. Riley. (London: N.A.G. Press Ltd.). Price 1s. 6d.

Modern developments in the science of aerial navigation have vastly enhanced the importance of aircraft instruments, besides which the increasing complexity of engines, controls and equipment have necessitated the development of many new or modified types of instruments, all of which must work with unquestioned accuracy and reliability under the most arduous conditions of temperature, weather and vibration. A sound knowledge of the operation of all these instruments is essential to the aircraft engineer, who must be capable of checking up and overhauling them in the course of general maintenance.

In this book, the essential principles and construction of all the various types of instruments are discussed in clear terms, and numerous illustrations showing working principles and arrangement of mechanism are given. A prominent position is given to an illustration showing a typical instrument panel of a modern heavy bomber, in which the large number and diversity of the essential instruments are clearly demonstrated.

Letters

A Point in English

DEAR SIR,—May I add a word to the point raised in the August 20th issue of THE MODEL ENGINEER regarding the correct terms to use in describing the different kinds of springs employed in mechanical contrivances?

It would simplify matters and avoid misunderstanding if writers would stick to a fixed rule in this connection. Personally, I always use the adjective "*helical*" to describe a spring having the shape of a screw thread, which shape may be defined as a curve of constant radius in a constantly varying plane at a constant angle to the axis depending on the pitch. This type of spring is chiefly used to exert a linear force parallel to the axis, though sometimes employed to exert a torsional force. On the other hand, I call a "*spiral*" spring one shaped like the springs used in clocks and watches to provide the driving force, which shape may be defined as a curve of constantly varying radius in one plane at right-angles to its axis, such springs being used exclusively to provide a torsional force.

My authority for these terms is "The New Standard Illustrated Dictionary."

The "*volute*" spring appears to be a combination of the two types mentioned, capable of performing both functions, its particular advantage being that it can be compressed into a smaller space than the true helical spring, relatively.

A so-called "spiral" staircase is, I believe, also called a *winding* staircase, which appears to me the more correct term.

Yours faithfully,

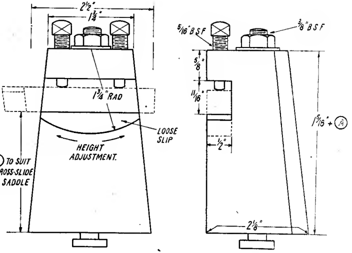
Bridlington. G. E. COUPLAND.

Tool Holders

DEAR SIR,—"Ned's" recent articles on Small Capstan Lathe Tools have contained so much sound and helpful information that I am sure he will pardon my drawing attention to several of his statements *re* front and rear cross-slide tool posts that are definitely not borne out in practice.

My own extensive experience of production methods, including the conversion of machines not originally designed for repetition work, prompts me to question "Ned's" statement that smaller tool posts than Mr. Ian Bradley's would be satisfactory for most light capstan work. Mr. Bradley's proportions appear to be very well thought out, and any reduction of dimensions would be most unwise. Skimping in any part of a repetition set-up, whether in the machine or equipment, is fatal if good results are required.

For the same reason, "Ned's" advocacy of a single set-screw for locking up tools cannot be allowed to pass unchallenged—sooner or later, disaster would be certain. However much a single set-screw is tightened, it can never have the same hold as two set-screws. Further, the use of two screws enables the tool to be held securely without any undue strain either on tool or toolholder.



"Ned" suggests adapting the American "bottle" type toolpost to capstan work, but is concerned about working close up to the chuck. This snag has long been overcome, notable examples being found in the Warner & Swasey capstan and Le Blond centre lathes. In both these machines the instantaneous height adjustment of the "bottle" is incorporated in a 4-*tool* revolving turret on cross slide. Holbrook's also used the idea in a single-tool clamp on their 6-in. centre lathes.

I give sketches of a single-way tool post embodying the principle, and can assure "Ned" that these boxes do their stuff to perfection and have no snags—it is only necessary to remember to bring *both* set-screws down on to the tool before commen-

cing to pinch up. The pinching up should be done gradually, alternately tightening each set-screw gradually till tool is locked, and no tendency for the adjustment to "wander" will then occur.

The sketches show a tool box to suit the average small lathe, which can very easily be made. The slot for tool should be either cast in or roughed out first, then mount on faceplate and *turn* in the radiused seat for adjusting slip.

The mistake of using small set-screws (made by "Helm" in his parting-off tool box—"M.E.," August 20th, 1942, issue), should be avoided—5/16 in. B.S.F. should be taken as a minimum. Small section tools should also be avoided—owing to lack of inherent rigidity—for repetition work on machines of 3-in. to 4½-in.-centres; ½-in. square tools should be used.

The box shown is ideal for all turning, forming and parting-off, and is equally satisfactory for the lightest of precision work or the heaviest of "heavy duty" work.

Yours faithfully,
Stockton-on-Tees. E. J. FISHER.

Clubs

The Society of Model and Experimental Engineers

The next meeting of the Society will be held in the Workshop, 20, Nassau Street, W.1, on Saturday, 3rd October, 1942, at 2 p.m. This will be a Stationary Engine meeting. A member has promised to run a model table engine, and other models will be welcomed. In addition, the running stand will be available for 2½-in. gauge locomotives.

Visitors' tickets for the meeting, and full particulars of the Society may be obtained from the Secretary, H. V. STEELE, 14, Ross Road, London, S.E.25.

Stephenson Locomotive Society

In view of the fact that the Society was born, in 1909, at Croydon, not far from the Brighton Main Line, and that the founders included enthusiastic members of the L.B.S.C. technical staff, it is not surprising that interest in matters Brighton is still to the fore. It was fitting, too, that Vice-President Brailsford, one of the Society's original sponsors, should preside on the occasion of Mr. F. C. Hambleton's paper, "Memories of the L.B.S.C.R.," read at 39, Victoria Street, London, S.W.1, on June 19th. With the aid of period photographs, illustrations and drawings, the lecturer sketched typical journeys between London and Brighton in Stroudley or early Billinton days, emphasising the Company's colours seen on the way, the signalling systems, locomotive types and other characteristics. As so many members wished to speak in appreciation, or to add their quota of reminiscence, it was unanimously decided to hold a "second innings" on the occasion of the summer Saturday meeting, when many "Brighton" relics and pictures were brought along for display. Messrs. F. Burtt and J. Pelham Maitland, welcome visitors, were able to give authoritative replies to several questions relating to past Brighton practice.

Acting General Secretary: J. H. SEAFORD, Woodlands Cottage, Fulmer Road, Gerrard's Cross, Bucks.

The Glasgow Society of Model Engineers

The Annual General Meeting was held on Saturday, 12th September, at the Club premises at 143, W. Regent Street, Glasgow, C.2.

The Club President, Mr. R. Anderson, having retired, Mr. A. J. Brown now assumes the Presidency, with Mr. P. Ribbeck as Vice-President. No other offices have been changed for the forthcoming year.

All the usual A.G.M. business was satisfactorily concluded, after which Mr. A. J. Brown read an extremely interesting paper on "Engine and Model Design and Practice."

The Club premises will, as usual, be open every Saturday evening, circumstances permitting, and a comprehensive programme for the coming season is being arranged.

Hon Sec.: J. W. SMITH, 785, Dumbarton Road, Glasgow, W.1.

York City and District Society of Model Engineers

The next meeting will be held on Friday, October 2nd, 7.30 p.m., at the "Bay Horse" Hotel, Monk Bar, York.

Hon Sec.: H. P. JACKSON, 26, Longfield Terrace, York.

NOTICES

The Editor invites correspondence and original contributions on all small power engineering and electrical subjects. Matter intended for publication should be clearly written, and should invariably bear the sender's name and address.

Readers desiring to see the Editor personally can only do so by making an appointment in advance.

All correspondence relating to sales of the paper and books to be addressed to Percival Marshall and Co. Ltd., Cordwallis Works, Cordwallis Road, Maidenhead, Berks.

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